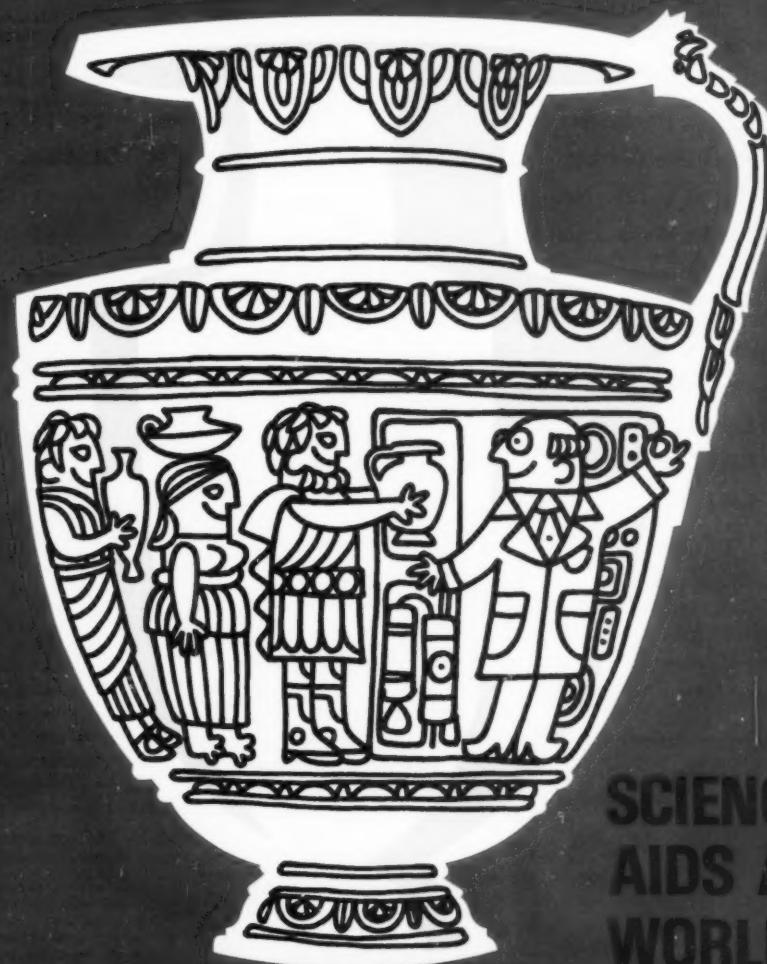


THE TECHNICAL NEWS BULLETIN OF THE NATIONAL BUREAU OF STANDARDS / September 1973

DIMENSIONS

NBS



**SCIENCE
AIDS ART
WORLD**

Science and Art Foundation
See page 203

A PUBLICATION OF THE UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

DIMENSIONS

NBS

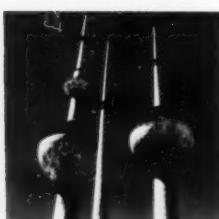
SEPTEMBER 1973 / Vol. 57, No. 9 / ISSUED MONTHLY

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DIMENSIONS / NBS will feature a new column—Highlights—that will give brief reports on upcoming Bureau work. Short progress reports on long-term projects will also be presented. See page 208 for this month's Highlights.

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The Institute for Basic Standards
The Institute for Materials Research
The Institute for Applied Technology
The Institute for Computer Sciences and Technology
Center for Radiation Research
Center for Building Technology
Center for Consumer Product Safety

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DIMENSIONS / NBS

Science Aids Art World



*Ending its exile in storage,
this smart-stepping fifth century
B.C. Greek horse is once again
on display at the Metropolitan
Museum; its authenticity vin-
dicated by science. (Photo
courtesy of The Metropolitan
Museum of Art).*

Afamous bronze horse owned by New York's Metropolitan Museum of Art was recently branded a 20th century forgery. However, thanks to science experts, among whom were materials analysts from NBS, the horse was found to be an irrefutably genuine work of antiquity.

This is but one of a number of instances where science comes to the aid of the arts and humanities.

Using new techniques of high-accuracy mass spectrometry developed at NBS, Bureau scientists Dr. William R. Shields, Dr. I. Lynus Barnes, and Thomas J. Murphy have undertaken a long-term program to measure lead isotopic ratios in known sources of ore and in archeological artifacts.

turn page

The procedure—a 100 percent improvement in precision over prior methods—can ascertain the approximate age and source of materials used to make ancient objects. Thus it can verify their authenticity and contribute to the confidence of art authorities in the validity of their collections. Applicable to geological materials as well, the technique is used in NBS analyses of moon rocks.

By determining the isotopic compositions of samples of lead removed from ancient objects, and comparing them to the compositions of ores from various sources, it is frequently possible to tell from which mining regions the leads in these objects could have come—and from which regions they could not have come.

Prior to the introduction of this method, archeological chemistry was able to identify ancient artifacts precisely, but only at great cost—i.e., destruction of the item examined.

Using the new technique, sample sizes have now become so minute

A typical 5th century Grecian jar identified by isotopic ratios of sample from its handle.



(as little as 1 microgram) that the quantities of material sacrificed are usually inconsequential.

300 OBJECTS STUDIED

So far, the NBS analysts have studied samples of lead from about 300 ancient objects. Among the materials analyzed are metallic leads, corrosion products, and lead extracted from such diverse materials as glasses, glazes, white lead pigments, leaded bronzes, silvers, and golds. The results confirm that these studies offer valuable evidence concerning sources.

Viewed as an archaeometric tool, high-accuracy mass spectrometry has two noteworthy characteristics: versatility in the materials to which it can be applied and relative insensitivity to the chemical histories of the objects studied. Since the isotopic composition of lead is relatively unaffected by the chemical and physical processes to which it is ordinarily subjected in its conversion from an ore to an artifact—and by subsequent burial and passage of time—the isotopic ratios determined today for samples removed from ancient objects are identical (or very nearly so) to those of the ores from which the leads were originally smelted. When isotopic ratios can be measured with sufficient precision, ore deposits may be distinguished from each other and matched with lead in the object.

Working with R. H. Brill of the Corning Museum of Glass on samples provided by J. M. Lambert, Director, Compagnie Francoise Des Mines Du Laurium, and B. B. Sheftan, Newcastle Upon Tyne Creek Museum, and others, NBS has analyzed a number of lead ores (mostly galenas, e.g., lead sulphide) from many countries, including a set of 17 samples collected from three mining areas north of Athens.¹

Also analyzed were a number of objects of known Greek origin, including bronze, silver, and gold coins minted in Athens between 300 and 40 B.C.,² containing lead from

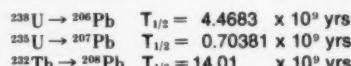
Greece's Laurium Mines. Analysis of other objects prove that Laurium lead was used as early as the 6th century B.C. Material from the handles of bronze hydra of the 4th, 5th, and 6th centuries B.C. indicate isotopic ratios in the narrow range characteristic of this lead. One bronze handle ascribed to either Spartan or Southern Italian manufacture showed lead ratios nearly identical to the average for Laurium leads and much different from ratios for any lead yet found in Italy. To date, the researchers have been able to determine the location of materials originating in England, Egypt, Greece, and Turkey, and to ascertain the isotopic variants characterizing them.

Occasional mysteries have been uncovered through this new analysis technique. For example, lead sheathing from a Mount Athos monastery roof was found to have an isotopic composition unlike any Greek lead, matching most closely that found in the cameing which fastens together the stained glass windows of medieval German Cathedrals. As yet, data are inadequate to determine whether the lead cameing is local.

LEAD, ONE OF THE FIRST METALS

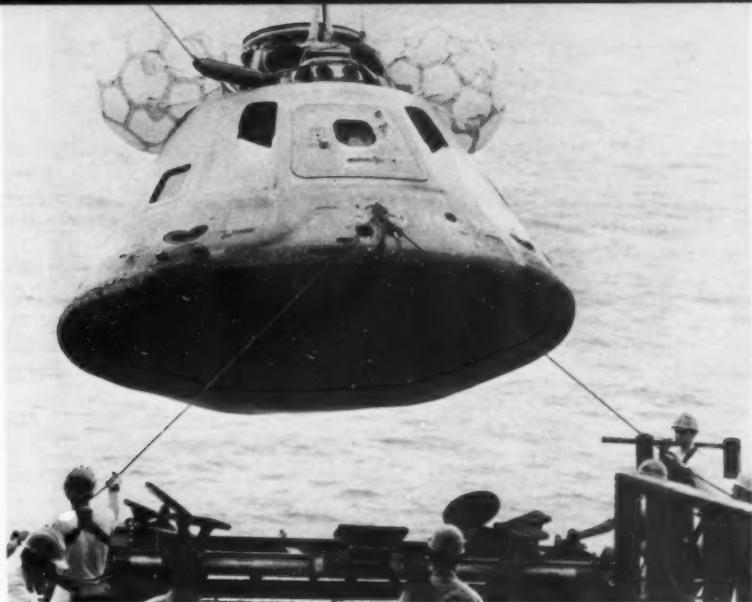
The element lead, one of the nearly universal constituents of ancient objects, was one of the first metals mined and used in the making of vessels, coins, and tools. Lead was added to ancient bronzes to improve the physical properties of the mix, and also in the refining of gold and silver.

Lead has four isotopes: ^{208}Pb , ^{207}Pb , ^{206}Pb , and ^{204}Pb . The first three of these are the stable end products of the radioactive decay of uranium and thorium according to the following:



Because of the significant difference in half-lives, the isotopes are not in equilibrium. The ^{208}Pb isotope is the most abundant, followed by ^{207}Pb , ^{206}Pb , and ^{204}Pb .

New Way To Predict Materials Failure



Spacecraft hooked and hoisted aboard the recovery ship U.S.S. *Ticonderoga* at the SKYLAB II Pacific Recovery Area. NBS scientists contributed to the success of the project. (Photo courtesy of NASA).

A novel method for testing the structural design and for predicting the lifetime of turbine blades, space ship windows, soft drink bottles, and other brittle materials has been devised by materials scientists at NBS. This research can lead, for example, to the production of safer glass bottles, with the consequent reduction in related injuries. The new test method is compatible with production line techniques and should make general test methods for pressurized glass containers feasible.

NBS failure prediction is based on analyses of how cracks grow. Crack growth in ceramic materials is caused by the combined action of applied load, moisture in the atmosphere, and other key parameters. Developed by Drs. S. M. Wiederhorn and A. G. Evans of the Institute for Materials Research, the method is an outcome of studies of basic fracture mechanisms in brittle materials.¹ The work is sponsored by the National Aeronautics and Space Administration (NASA), the Office of Naval Research, and the Air Force scientific laboratories at Wright-Patterson Air Force Base.

NBS data have already been used in acceptance tests for materials used in NASA's new SKYLAB space laboratory and for porcelain electrical suspension insulators. Data are also being collected for the glass to be used in the Space Shuttle and for the ceramic materials used as gas turbine components, such as silicon nitride and silicon carbide. Initially applied to ceramics and glass, the method can help determine design acceptability of any brittle material.

TECHNICAL DETAILS

In many ceramic systems, slow crack growth precedes fast fracture. Strength, therefore, is dependent on time. The successful structural exploitation of these materials requires a detailed understanding of this time-dependent behavior so that accurate failure predictions can be made. The accuracy of failure prediction is very substantially enhanced by incorporating a component proof test prior to service. It is generally considered, therefore, that effective proof testing is an essential prerequisite for the successful structural application of ceramic materials. The pri-

mary objective of the work is to present an analysis based on fundamental principles which enables proof test conditions to be accurately selected, thereby ensuring the "in-service" component lifetimes demanded by a particular application.

The analysis considers a rapid proof test (which does not lead to any significant slow crack growth in the unbroken components) and then a more practically realistic "slow" proof test (which may permit slow growth, and hence lead to strength degradation in the unbroken components). The analytical predictions are verified in a series of critical experiments. General considerations of time dependent fracture in brittle materials are then developed, which enable techniques for the rapid evaluation of the important crack propagation parameters to be established.

¹ Evans, A. G., Wiederhorn, S. M., *Proof Testing of Ceramic Materials—An Analytical Basis for Failure Prediction*, NBS Report for ORN—NBSIR 73-147. Available from the National Technical Information Services, Springfield, Va. 22151, as COM 73-10989 for \$3 per copy or 95 cents per microfiche.



Nation's Fire Services Program Strengthened

**Dr. Bernard M. Levin
Appointed Manager**

THE NBS Fire Services Program which helps provide better equipment to the firefighter and better management aids to the fire chief, has a new manager: Bernard (Bud) Levin.

Announcing the appointment, Dr. Richard W. Roberts, NBS Director, commented: "The Fire Services Program is the primary current Federal program directly responsive to the needs of fire departments. It is an important part of a broad NBS program to reduce the Nation's fire toll."

NBS responsibilities for fire safety date back to 1904 and more recently have been emphasized in the Fire Research and Safety Act of

Firefighters engage in a very dangerous profession...NBS hopes to help reduce the Nation's fire toll through a strengthened fire services program aimed at improving the fireman's effectiveness.

1968 (PL 90-259) in which Congress stressed the need for more effective measures of protection against the hazards of death, injury, and damage of property.

MORE ON DR. LEVIN

Dr. Levin, acting chief of NBS fire services since 1972, will put new stress on practical measurement problems, with solutions translated into meaningful firefighting procedures, e.g., ways to evaluate new procedures and equipment; development of standards and purchase specifications for improved firefighter equipment; criteria for local fire protection planning; and design of data systems.

Dr. Levin is a member of the Steering Committee of Project FIRESCOPE (IC) which is a cooperative effort of several major California fire departments, the State of California, and the U.S. Department of Agriculture Forest Service to develop improved command procedures in attacking major brush fire disasters.

A graduate of Colgate (B.A., 1951) and the University of North Carolina (M.A., 1954, Ph.D., 1956), Dr. Levin has won a number of awards and authored numerous articles and research reports. He has been cited three times for Outstanding Performance at NBS. During his career at NBS he has led the NBS Postal Mechanization Project and initiated and led the NBS Northeast Corridor Simulation Project. He developed the initial plan for the NBS Law Enforcement Laboratory and played an important role in the development of the initial plan for the current NBS fire program. He is a member of the National Fire Protection Association Fire Department Equipment Committee. In 1970, Dr. Levin was selected for the President's Executive Interchange Program in which he served as Director of Special Projects, Corporate Planning,

American Airlines. In 1966 he served as a Commerce Department Science and Technology Fellow in the Bureau of Public Roads.

SOME NBS FIRE SERVICES PROJECTS

In addition to helping initiate the California FIRESCOPE (IC) Project (also known as the Multiagency Command and Control System Field Control Operation Project), the NBS Fire Services Program is concerned with a number of activities aimed at establishing the "technical infrastructure" for improving the effectiveness of fire departments and improving the safety of the firefighter's job—the most dangerous in the country.

- NBS has worked with fire officers in Prince Georges County, Md., to develop a purchase specification for a turnout coat, the coat firefighters wear while extinguishing fires. The coats are usually too heavy—often over 8 pounds—and the outerlayer is often excessively flammable. The coats purchased by Prince Georges County using the purchase specifications have a number of desirable features, including weighing less than 6 pounds and being relatively nonflammable. If no unexpected problems arise in current field tests, they will serve as a model for future turnout coats throughout the country. Already New York City has used the specification as a basis for their turnout coat purchases.

- Another major project—Task Analysis—seeks to quantify and document what the firefighter actually does so that engineers can use these data in attacking the fire problem: A basic question is how long does a fireman usually stay in a fire? The firefighters insulated turnout coat contains metabolic heat. If this heat is not dissipated, the fireman can only work a short while in the fire area. Again, in view of other factors limiting a firefighter's ability to stay long in a burning building, is it necessary to dissipate

the heat at all? Task Analysis is a first step toward answers based on technical information.

- Using cost/benefit analysis, answers could be provided for such major puzzlers as: How large a fire department is needed, and how can it be justified? A National Fire Protection Association Technical Committee is currently studying this question and the NBS Fire Services program will develop and generate valuable technical information for use by the Committee.

- Comprehensive regional plans are being prescribed as prerequisites for proposed Federal block-grants. In developing plans, how much responsibility should be put on builders and property owners for built-in sprinkler systems and the like to lessen the firefighter's burden? Techniques for taking such factors into consideration in municipal planning need to be developed and tested.

- A major project is the Modular Incident Reporting System, developed by a Management Information Study Committee (consisting of representatives of fire department officials from the Washington and Baltimore metropolitan areas) with the aid of NBS. Now being tested by the Prince Georges County (Md.), Arlington County (Va.), and Annapolis (Md.) fire departments, the system provides data to fire chiefs about the operations and activities of their departments. Los Angeles City, Los Angeles County, Ventura County, and Burbank (Calif.) have decided to implement the system.

Drawing on the resources of the entire NBS and employing a number of methods (e.g., contract research, seed-money, liaison and advisory services, demonstrations, etc.), Dr. Levin said that his program will have a balance between solving problems of immediate concern to the fire services and developing a base for a systematic program to help the fire services.

Highlights

NBS TO HOLD OPEN HOUSE

The first open house to be held at the Bureau's Gaithersburg, Md., laboratories since its dedication in 1966 will take place on October 26-27, 1973. Approximately 50 laboratories will be open for inspection; several special exhibits will be featured—including those on noise and energy; and a number of films on the Bureau's work will be shown.

October 26 will be devoted primarily to prearranged group tours. On October 27th, the laboratories will be open to the general public. Information and maps will be provided; guides will also be available.

For additional information, write to the Office of Information Activities, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

WWVB GOES ROUND-THE-CLOCK

Station WWVB, which broadcasts on the low frequency of 60 kHz, began uninterrupted transmission on July 4. Until then, the low-frequency broadcasts had been subject to biweekly shutdown periods for maintenance.

The continuous service will be particularly welcomed by two user groups for whom WWVB's broadcasts are particularly important: members of the North American Power System Interconnection Committee, who synchronize the frequency control of their electric

power networks by means of WWVB, and earthquake monitoring networks, especially in California, which use the broadcast signals to place seismometer and building-motion sensors in different locations on a common, accurate time scale.

SIXTH MATERIALS RESEARCH SYMPOSIUM

Standard Reference Materials and Meaningful Measurements will be the subject of the 6th Materials Research Symposium to be held October 29-November 2, 1973, at the Bureau's Gaithersburg site. The principle purpose of this Symposium is to answer the question "How may Standard Reference Materials be used more effectively in bringing about meaningful measurement both on a national and international scale?" The Conference will also explore the problems of measurement and the need for SRM's in industry and technology, science, health, and environment.

For additional information on the Symposium, contact Mr. Ron Johnson, National Bureau of Standards, B354 Materials Building, Washington, D.C. 20234 (telephone 301/921-2835).

RAMAN SPECTROMETRY ANALYZES BUBBLES IN GLASS

Recent experiments have demonstrated the usefulness of Raman scattering for semiquantitative measurement of the content of gas-filled, bubble-like inclusions in

glasses. Such measurements can lead to improved glass quality and reduced gas emissions during processing.

The light scattering technique shows good sensitivity for N₂, O₂, CO₂, and SO₂ and is expected to show similar sensitivity for NO, CO, and N₂O, and hydrocarbons. Bubbles down to 0.5 mm in diameter have been measured with a good signal-to-noise ratio. The Raman scattering technique is nondestructive, reasonably rapid, demands little sample preparation, and can be used at elevated temperatures.

SAMPLING AND ANALYSIS OF CHESAPEAKE BAY SEDIMENT AND ORGANISMS

Because a number of food chain organisms can concentrate trace elements, the analysis of water alone may not be a good indicator of water quality. Determination of trace elements in the water-sediment-biota system gives a much more complete picture of interactions of trace elements in the aquatic environment and their ultimate impact on man.

A program involving Chesapeake Bay sediments and biota and Patuxent River sediment, biota, and water is underway. In both cases, the program must include improved sampling techniques to assure that samples taken back to the laboratory for analysis are as unaffected as possible by contamination during sampling. A "noncontaminating"

sampler is being developed for sampling shallow water (<30 meters).

Several trips were made on the Bay and the Patuxent to gather sediment and biota samples for analysis. These are being analyzed using nondestructive neutron activation analysis. Correlation of the trace element profile for the various system components may indicate key links in the concentration of undesirable trace elements in the food chain. This information should be useful in the development of overall criteria for water quality determination.

TECHNICAL ANALYSIS

At the request of the Federal Highway Administration, NBS is conducting a 2-year study of the social and environmental effects of highway locations. A state-of-the-art review of the literature is presently underway. The objective of the study is to determine the impact of road construction on the attitudes, values, activity patterns, and quality of life of people who live near highways. The results obtained will be used to assist inter- and intra-state highway planners in route selection and in improving communication between highway officials and concerned citizens.

HURRICANE WIND STUDY

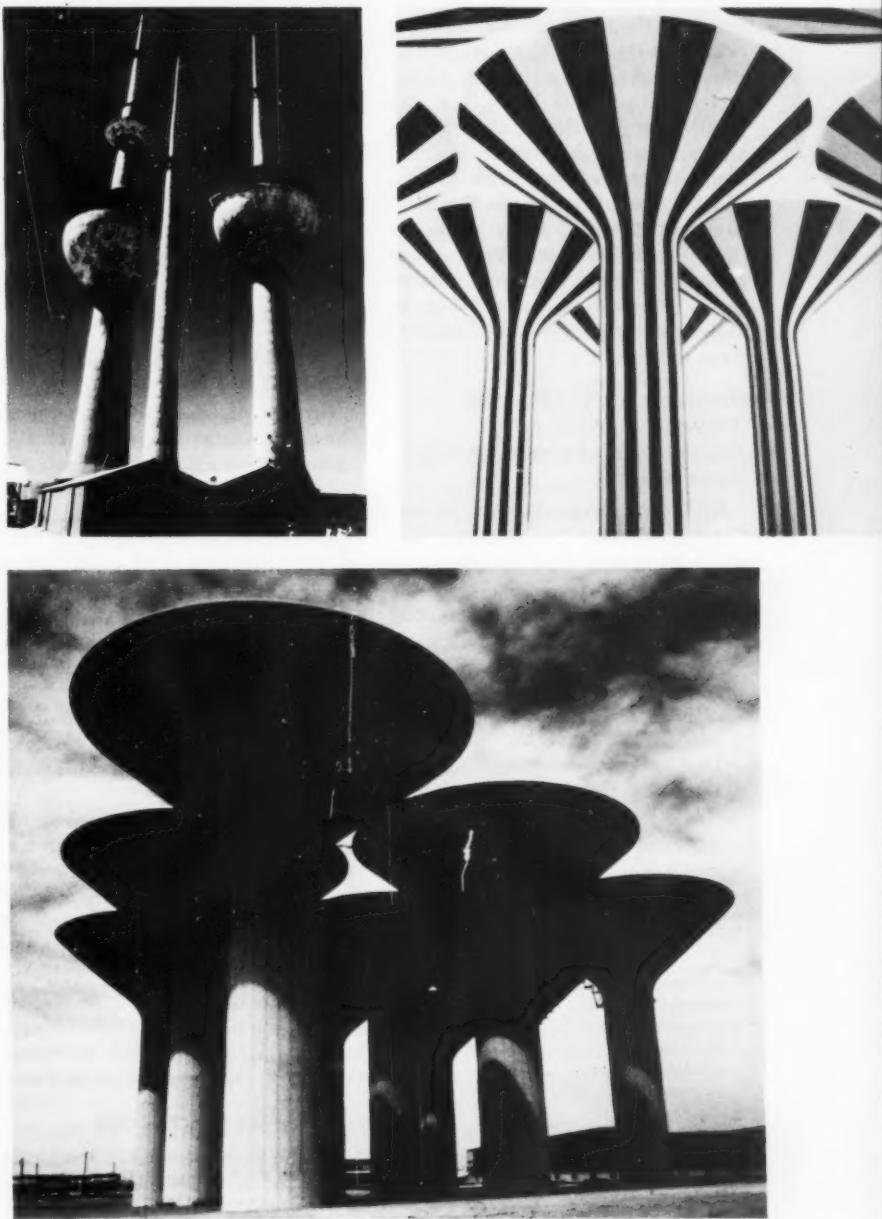
NBS is starting a 2-year study to improve criteria by which the Port Authority Facilities located along the Gulf and Atlantic Coasts can be designed to be more resistant to hurricane-force winds. Under Maritime Administration sponsorship, NBS will establish wind-data gathering installations in several of the 45 ports along these coasts. It is anticipated that hurricane data gathered over the next few years will assist in establishing an early-warning period of impending hurricanes and in locating an impending strike. These data will be used to develop the design criteria to make buildings more resistant to high winds.

CONSULTATION TO KUWAIT ON URGENT CORROSION PROBLEM

At the request of the Government of Kuwait, through the U.S. Department of State, NBS is providing technical consultation on the corro-

sion of large-volume water storage facilities in that country. An NBS metallurgist, Gil Ugiansky, recently traveled to Kuwait to inspect the facility, observe corrosion damage, and collect water and alloy samples for analysis and identification.

turn page



HIGHLIGHTS *continued*

NBS INVESTIGATION INTO MARYLAND GAS EXPLOSION

NBS has been asked by Prince George's County, Md., officials and by the National Transportation Safety Board (DOT) to help investigate the recent Bowie, Md., gas explosion that took three lives. The Bureau will examine the house's gas meter for possible leaks, test the plastic gas pipe that fed the house, and analyze soil from around the house for gas content. This project will be carried out in the Bureau's well-established Failure Analysis Program, which is aimed not only at analysis of actual failures of materials in service but also at trying to understand more fully the causes of these failures.

STANDARD KEYBOARDS FOR TYPEWRITERS, DATA ENTRY DEVICES, AND COMMUNICATIONS TERMINALS

NBS, in cooperation with the General Services Administration, has undertaken development of a single keyboard arrangement for typewriters, data entry devices, and communications terminals. Cur-

CORRECTION

Due to typographical errors in the June issue, certain SI-related symbols in the following chart were not shown in the proper italic form. The symbols in correct typefaces are repeated below.

Unit	Symbol
elementary charge	e
electron mass	m_e
proton mass	m_p
Bohr radius	a_0
electron radius	r_e
Compton wavelength of electron	λ_c
Bohr magneton	μ_B
nuclear magneton	μ_N
velocity of light	c
Planck constant	h or \hbar

rently, there are separate and different voluntary standards for each of these applications. In the development of this standard, NBS is working closely with major vendors through the American National Standards Institute Committee on Office Machine Standards. It has been determined that the basis for the single keyboard standard will be the electric typewriter arrangement. Additional keys will be added to accommodate all of the graphic and control characters of the American Standard Code for Information Interchange (ASCII). Also, substitutions for special OCR (optical character recognition) requirements will be identified. A draft standard should be available for processing and coordination in early 1974.

DATA TABLES OF RARE EARTH ELEMENTS ISSUED

Tables of Selected Chemical Thermodynamic properties of the lanthanide (rare earth) elements and their compounds have been issued as Technical Note 270-7, part of a revision of Circular 500. The compilation is the only recent set of authoritative thermodynamic tables for a group of chemical substances that are similar to one another in many ways. These Tables can be ordered by SD Catalog No. C13.46:270-7 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for \$1.25.

The lanthanides have become increasingly technologically important as their properties and the subtle distinctions between them have become better understood, and as important new uses for them have developed in catalysts applicable to environmental problems, in optical devices such as lasers, phosphors, and filters, and in other materials having unique desirable properties.

NEW SAFETY COLOR CODE

At the request of the American National Standards Institute (ANSI) and the Federal Highway Adminis-

tration of the Department of Transportation, the NBS Sensory Environment Section developed a printed safety color code for signs, tags, and labels used on highways and in factories, offices, and homes. The colors used in the standards are described in terms of lightness and hue. The Department of Transportation has already adopted the code and is using it for labeling such hazardous materials as explosives, flammable gas and liquids, poisons, and radioactive materials shipped in interstate commerce. The code is also being reviewed for use by other Federal agencies such as the Occupational Safety and Health Administration, the Atomic Energy Commission, and the National Highway Safety Board.

NEW SRM CATALOG AVAILABLE

A new edition of the Standard Reference Materials Catalog is now available. This catalog lists and describes the Standard Reference Materials (SRM's), Research Materials (RM's), and General Materials (GM's) currently distributed by NBS, as well as many of the materials currently in preparation.

Order by SD Catalog No. C13.10:260 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for \$1.25.

NBS-AUSTRALIAN COLLABORATIVE PROGRAM

A collaborative research program will be carried out for 1 year between NBS and the Department of Supply of Australia. The aim of the program is to establish the relationship between temperature and the thermoelectromotive force and other characteristics of the new nickel-base thermocouple alloys, Nicrosil and Nisil recently developed by the Australian Department of Supply. Australia will sponsor a guest worker who will work with the Bureau's Heat and Cryogenics Divisions.

POLLUTION-MEASURING DEVICE DEVELOPED

SENSITIVE NITRIC-OXIDE DETECTOR IGNORES OTHER CONTAMINANTS

A highly specific and sensitive pollution measuring device has been developed at the Bureau. Using the principle of laser magnetic resonance (LMR), the device responds to nitric oxide (NO) and ignores the presence of other gases in the sample.

Oxides of nitrogen, and especially nitric oxide, are among the most pernicious pollutants found in the atmosphere. Produced by high-temperature combustion processes, NO is a major cause of photochemical smog. When combined with water vapor it forms nitric acid. It also appears to remove ozone from the atmosphere. Ozone protects the earth from the harsh ultraviolet radiation of the sun. It is not yet certain what concentrations of NO are necessary for the ozone destruction to be environmentally important.

In order to effectively combat the rise of NO pollution, it is essential to have accurate measurements of NO concentrations in the air and at the source. No program of pollution control can succeed unless the pollutant can be identified and measured. There is a need for an instrument that can accurately measure small amounts of NO in a sample of air without confusing the NO with other gases, such as nitrogen or nitrous oxide.

Concern about the effects of NO in the stratosphere, the need for routine measurements of urban NO concentrations, and the legal requirements for measuring NO concentrations in vehicle exhausts have prompted the development of a sensitive, specific NO detector.

The NO device developed at NBS uses a carbon-monoxide laser operating at 5.649×10^{13} Hz (5.307 μm wavelength) to probe a sample of gas. NO is a magnetically active molecule whose energy levels split in the presence of a magnetic field. This Zeeman effect is particularly pronounced at the wavelength chosen for the laser, so that a relatively small field (0.1 tesla) is sufficient to allow observation of the effect. Because no other contaminant has a Zeeman effect near this particular laser frequency, no other gases will absorb the radiation, thus providing highly NO-specific detection.

High sensitivity is obtained by modulating the magnetic field at about 12 kHz and locking the infrared detector to the same frequency. Thus, noise at all other frequencies is eliminated. The output signal is the first derivative of the absorption line and is plotted as a function of magnetic field. The peak-to-peak height of the signal is proportional to concentration over a wide range of NO partial pressure (1 to 10^{-4} Pa or 10^{-2} to 10^{-6} torr).

NO measurements are needed over a range of concentrations from several hundred parts per million (as in automobile exhausts) to one part per billion (estimated lower range of stratospheric concentration). The NBS device could probably be engineered to cover this range using different configurations; work on a prototype of the one-part-per-billion device has begun. At these low levels, the specificity of the LMR device is particularly useful because other

pollutants are present in much higher quantities.

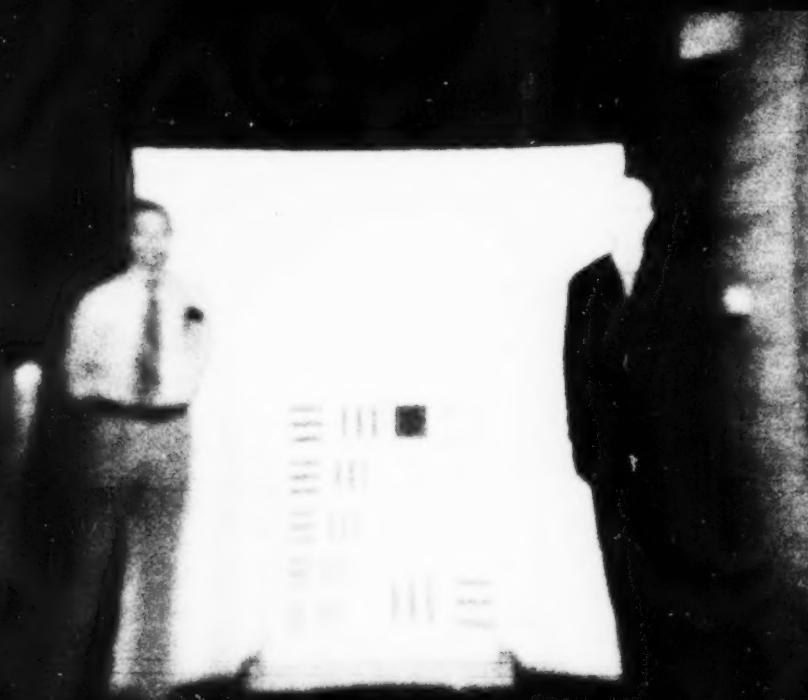
APPARATUS DETAILS AND MORE TECHNICAL DATA

The NO absorption cell is located inside the laser's resonant cavity, so that the infrared radiation makes many passes through the cell. This provides maximum sensitivity for a given NO cell length.¹ Two solenoids, coaxial with cell and laser beam, surround the cell; the outer one provides the basic dc field at 0 to 0.1 tesla, while the other is driven by a 12-kHz reference oscillator and audio amplifier. The laser beam, Zeeman-modulated at 12 kHz, is detected with a gold-doped-germanium infrared detector. The detector signal is fed to a lock-in amplifier (locked to the reference oscillator) that drives a chart recorder.

Doppler broadening of the signal line width is the major broadening effect at pressures up to about 1,300 Pa (about 10 torr), the maximum pressure used in this device. Beyond this pressure, collision broadening dominates and reduces the signal amplitude. The Doppler width at room temperature is about 125 MHz.

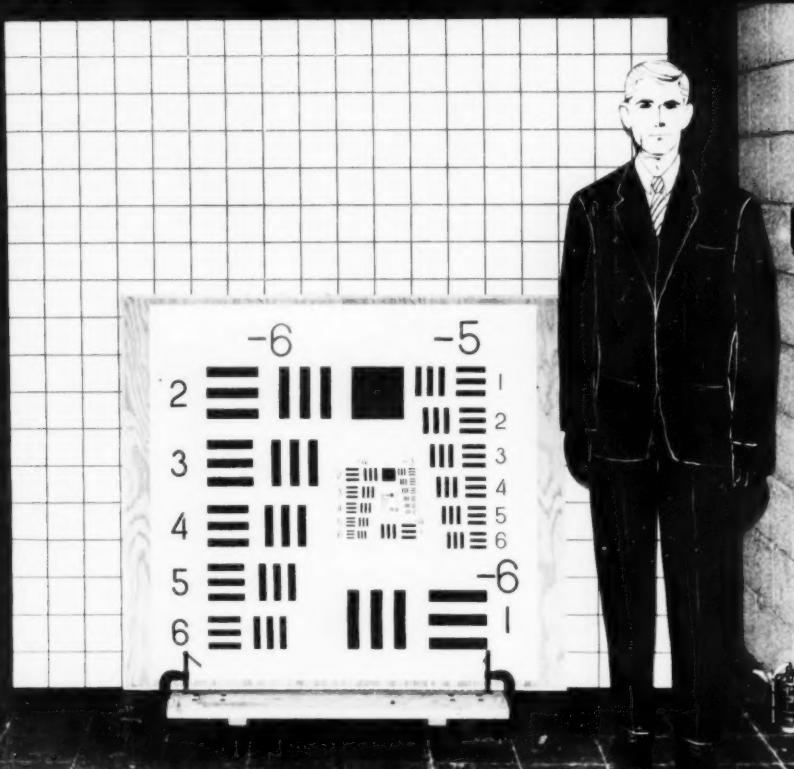
The laser is operated just above threshold power, at about 10 mW or less, to avoid saturating the absorption and causing nonlinear effects. It was also found that the oscillating magnetic field biased the laser's power somewhat; future versions of the apparatus will provide better isolation from the field, yielding increased sensitivity.

¹This technique represents an extension of that reported in the Technical News Bulletin 56, No. 9, Sept. 1972, p. 221, in which the sample cell was placed outside the laser.



Photograph of a man, dummy, and test charts made in almost complete darkness by using night vision equipment.

Test chart and dummy used by NBS scientists in developing a standard for night vision equipment.



As part of a program for developing passive night vision equipment, scientists at the Bureau's Law Enforcement Standards Laboratory (LESL) have developed a test chart for evaluating optical factors affecting intensifier devices.

NBS Aids

NEW tests for evaluating passive night vision devices are being developed for the Justice Department's National Institute of Law Enforcement and Criminal Justice (NILECJ) by the Bureau's Law Enforcement Standards Laboratory (LESL). NILECJ is part of the Law Enforcement Assistance Administration.

Unlike active devices, passive ones do not require an infrared source to enhance the illumination level; passive devices also provide a broader field of vision since the field is not dependent on the beam width and luminance of an infrared source.

Passive surveillance devices were developed by the military for use in Viet Nam and are now being privately produced for nonmilitary purposes. Using them, police are able to see and photograph activities otherwise shrouded in darkness. Such devices are also in demand by the Border Patrol; the Bureau of Customs; and by the Maritime Administration for night navigation, search and rescue, and port security operations. Some ver-

developing standards for night vision
ureau's Law Enforcement Standards
oped test equipment and procedures
affecting performance of passive image



NBS scientist Joseph Richmond adjusts camera to night vision detector in order to photograph optical chart and dummy in NBS Law Enforcement Standards Laboratory.

U.S. Night Vision Market

sions can also be mounted as rifle sights.

A substantial market potential has been forecast for these devices, and prices now range from \$2,000 to \$7,000. In the scramble by more than a dozen firms to enter this market, the need for performance standards has quickly become evident. Production of the intensification tube used in this equipment is still an art. Not only does performance differ from one manufacturer to the next, but even more importantly, manufacturers have been unable to maintain production at consistent quality levels. The test equipment and procedures developed at NBS should contribute to solving this major quality-control problem faced by a rapidly burgeoning industry.

For a night vision device to be effective, it must form a useful image under ambient illumination levels too low to permit vision, even with the aid of optical devices such as binoculars. For an image to be useful, it must be bright enough to be seen, but not so bright as to dazzle the viewer, and of a quality to yield the desired information. It is com-

paratively easy to evaluate optical gain, the ratio of image brightness to scene brightness. The evaluation of image quality is more difficult. There is no single parameter that is generally accepted for evaluating the quality of a simple image such as a photograph, and the photoelectronic image-forming process used in night vision devices is much more complex than the optical process used to form an image in a camera.

Test procedures have been developed at NBS to evaluate the following parameters, related to image quality of night vision devices: 1) optical gain and optical gain stability, 2) image brightness and brightness uniformity, 3) cathode and screen quality, 4) light induced background, 5) light equivalent background, 6) contrast transfer function, 7) distortion, and 8) flare.

Parallel to the development of these test procedures, another study was conducted to ascertain the image quality requirements necessary for equipment used to perform the surveillance mission of law enforcement agencies. The

most stringent operational requirement is the ability to identify an individual in a photograph taken through a night vision device, as when surveillance data are submitted in court as evidence. The military has carried out similar studies with the goal of identifying objects rather than individuals, e.g., tanks, aircraft. However, based on literature surveys and discussions with leading experts in the field, the quantitative data developed in the military studies were not deemed fully adequate to identify people with the precision required for law enforcement needs. Therefore, the required image quality was determined through the NBS experiment.

The night vision equipment project is being directed by Mr. Marshall Isler of LESL and conducted by Mr. Joseph Richmond of the Optical Radiations Section and Dr. Gary Yonemura of the Sensory Environment Section. A supporting contract in the area of lens evaluation has been awarded to the Photographic Engineering Division of the Naval Ordnance Laboratory, White Oak, Md.

WEIGHTS, MEASURES, AND THE NEW EQUITY

Excerpted from a speech given by Dr. Richard W. Roberts, NBS Director, at the National Conference on Weights and Measures in Minneapolis, Minn., on July 24, 1973.

ONE of the first things I heard about when I joined NBS was the Office of Weights and Measures. This Conference is an important part of my orientation as new Director.

I am impressed by the purposes of the National Conference on Weights and Measures and even more impressed by the way you have accomplished your purposes over the years. I was reminded, when I began to learn about you, of a line from "A Man for All Seasons." In that play, a boatman says of the fares fixed by law for transporting people on the river, "Chelsea to Hampton downstream a penny ha'penny, Hampton to Chelsea upstream a penny ha'penny; whoever makes the regulations doesn't row a boat."

I think it is true in virtually all fields. The men who make regulations and the men who enforce them are not the ones who row the boats. It is true in your field too. But there is more communication among those groups in weights and measures administration than in any other field I know.

Before I begin to talk of new ideas, let me assure you that I am well aware of the traditional needs

of the weights and measures community and of the Bureau's traditional role in meeting those needs. But, as a neophyte member here, I have the natural prerogative of making some suggestions of ways in which the Conference and the Bureau might improve the lot of the working weights and measures man. For example, I think it would be worthwhile for the Conference to develop a comprehensive blueprint for building an effective weights and measures enforcement program. Already there exist many basic tools that the conference has developed. But there is no reference to guide the weights and measures supervisor in planning his operating program.

I think we at NBS could increase our assistance to you in five areas. First, there is a critical need for an overall look at the resources that you currently expend on weights and measures enforcement. Such information is crucial to us if we are to meet your needs. It is also vital to you in your own attempts to evaluate program efforts and to secure additional program resources. To this end, the Office of Weights and Measures recently forwarded to the States survey questionnaires designed to provide us with the first complete census of weights and measures officials. This is the first step of a planned national survey covering all facets of weights and measures administration.

Second, it is important that we work together in the development of performance criteria with which you can measure your program output. It is difficult to comprehend how you or I can increase our program resources until we can demonstrate the importance and usefulness of what we are doing. The Office of Weights and Measures has made some important progress in finding ways for you to make such evaluations.

Third, keeping abreast of changing market conditions and changes in weighing and measuring devices and systems necessitates a continuing education program. You must look to sharing that responsibility with us by developing or expanding your own in-house training capability. We, in turn, can step up efforts to generate training materials and visual aids that can greatly assist you in this training effort. We will also continue to conduct training as part of our ongoing education program.

Fourth, I am also aware that there are pressing engineering problems relating to commercial measurement being faced in most State and local jurisdictions. New technological developments, such as the computerized checkstand weighing system or the electronic railway in-motion weighing system, pose measurement problems that must be resolved. Also, there is a need for solving problems in meters used to

measure liquid feeds and the moisture in grain. This has been a long-standing problem and we are placing high priority on its solution.

Last, many of you would like to update your programs through revision of existing laws, regulations, and operating procedures. Many of these changes require some assistance, either through the analysis of existing laws and regulations or through appearance by experts before legislative hearings. The Bureau is willing to provide whatever assistance the Office of Weights and Measures can give.

Before presenting one more new idea, let me digress a minute on the interpretation of words. People are too often confined by the way they define the words used to explain their responsibilities. For example, I think the Department of Commerce, because of a misinterpretation of the word commerce, is known as the agency of business. But commerce is not synonymous with business. Commerce is an ecology, a tenuous balance of manufacturers, entrepreneurs, wholesalers, retailers, and consumers. No one part of that ecology is more important than the others; no part is more worthy of representation than the others; it is the balance that represents the health of commerce.

Equity. I have heard it said that a weights and measures official cannot assure equity in the marketplace by being neutral. Neutrality actually is bias against the con-

sumer, because he is the most powerless participant. That concept jarred my thinking and I began to reconsider my own definitions of equity.

It occurred to me: Doesn't real equity require that the consumer have safe products? Doesn't real equity require that the consumer be protected from environmental pollution? Doesn't real equity demand that the consumer be protected against power and energy shortages?

I think so. And I think it is important for the weights and measures official to become an activist in these areas. You will not necessarily have direct responsibility. In most cases the State and local agencies that look after these matters are separate from the weights and measures operation. But you must be prepared to provide measurement support to them just as we at NBS are gearing up to help them.

At NBS we have seen this increased emphasis on consumer rights in the marketplace; and I think we have done a good job of staying with the trends. You are all familiar with your fair packaging program, and many of you have been an integral part of it.

But beyond this, consider product safety. NBS has been a leader for years in the determination of fabric flammability. The flammable fabrics laws grow stricter as the Congress responds to the people's demand for protection. NBS has worked hard to keep the technical

base for enforcing the laws up to the increasing levels of stringency.

Also in product safety, NBS has been conducting a project to develop ways for measuring the danger of sharp points and edges in children's toys. Several simple and portable devices have been developed to enable inspectors in the field to aid manufacturers in assuring the safety of products.

The point is this: How many of you are familiar with measurement problems in fabric flammability or in sharp points and edges on toys? I think you should be. I think you should not only be ready to help other State and local officials with such problems, I think you should be seeking them out and telling them that you can help them. That is what I mean by taking an activist role in assuring equity.

So this is my message. Equity is a very comprehensive and very complex concept. I think that we have not fully appreciated it and that we have not fully prepared for it. If the public demands for real equity are not to descend on your heads unexpected and unwanted, you must understand the full concept of equity and take positive action to meet it.

I pledge that NBS will provide you full access to its work in all fields of public concern. I ask only that you begin to look at what it is that the public really wants from the marketplace and then to see to it that you are prepared to help them achieve it. If you can accomplish this, then equity will indeed prevail.

Product Information Guide Published

NBS recently published a 119-page listing of nearly 700 product areas and over 1,000 standards titles that apply to products found in and around the home; standards pertaining to foods, beverages, and drugs are not included.¹

The publication, entitled "Tabulation of Voluntary Standards and Certification Programs for Con-

sumer Products," can be used by consumers; labor unions and trade associations; manufacturers, distributors, and retailers; Government agencies; and standards-writing organizations as a guide to which products have available standards, the designations and titles of these standards, and whether these standards deal with safety, per-

formance, or some other characteristic. It does not attempt to evaluate the adequacy of the listed standards. Also supplied are the names and addresses of the 103 organizations which have standards listed.

¹ NBS Technical Note 762, Tabulation of Voluntary Standards and Certification Programs for Consumer Products. Order from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, by SD Catalog No. C13.46:762 for \$1.25 per copy.

PICOSECOND-PULSE PRECISION IMPROVED

PICOSECOND-PULSE measurements have taken a significant step forward with the development of an improved bandwidth autocorrelator. By employing a sliding short and a pyroelectric-film detector, the autocorrelator overcomes inherent limitations of earlier systems, particularly oscilloscopic methods of pulse measurement.

According to the developer, Robert A. Lawton, a physicist in the Bureau's Electromagnetics Division, this technique provides a direct measurement of autocorrelation functions of picosecond-domain electrical pulses. Developed at the Bureau's Boulder Laboratories, this new system provides, for the first time, a method of determining the autocorrelation function of picosecond-domain electrical pulses without requiring oscilloscopic-waveform measure-

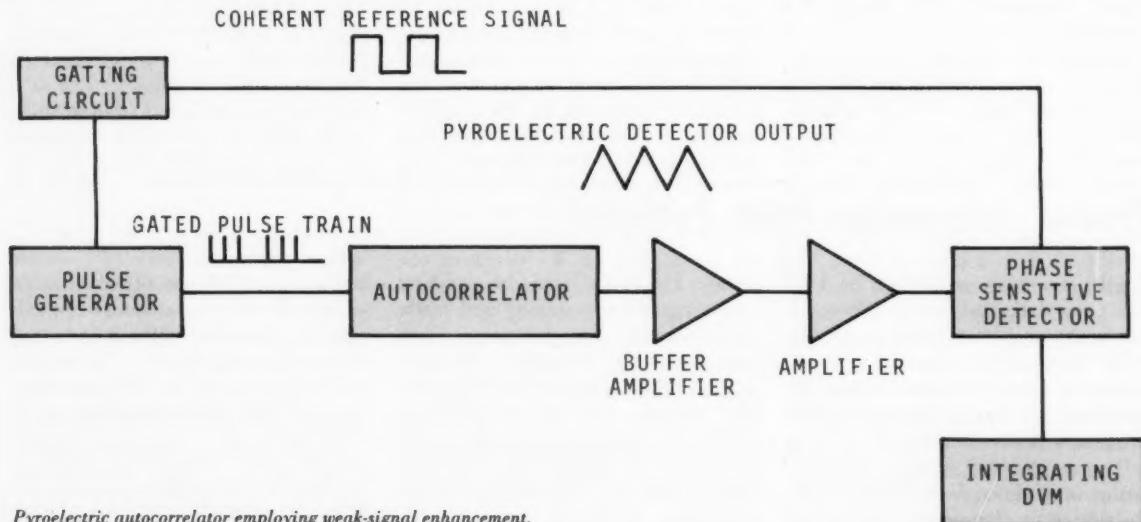
ments. Consequently, the technique offers an alternative method to numerically processing oscilloscopic data to obtain the autocorrelation function. Eliminating those oscilloscopic measurements and their inherent limitations makes improved autocorrelation measurements possible.

The autocorrelation function, derived from this measurement method, yields such things as the first-transition and duration times of certain pulses which, under some conditions for ordinary oscilloscopic techniques, are at least difficult if not impossible to measure. The pulse-power spectrum can also be obtained from the autocorrelation function.

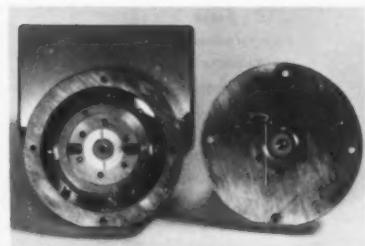
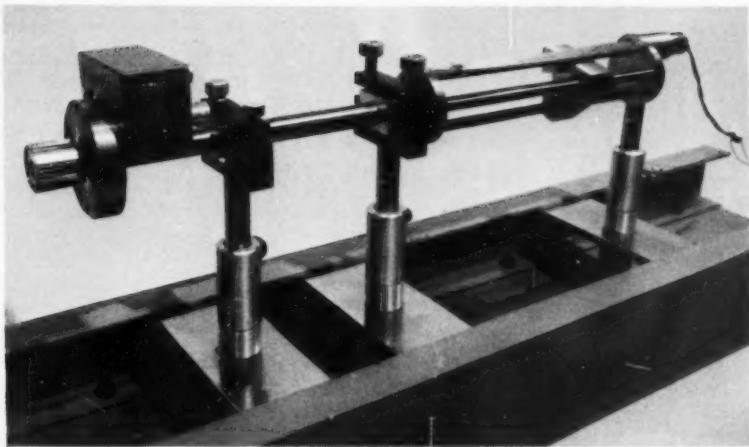
Measuring fast-pulse transition times has become increasingly important in time-domain reflectometry (TDR), a technique which

rapidly pinpoints the location of faults in coaxial and waveguide microwave systems. Additionally, pulse techniques together with fast Fourier transform methods permit the rapid determination of frequency characteristics of various instruments and the properties of materials. Of rising importance are precision pulse measurements for radar reconnaissance and distance measurement, digital data transmission and processing, nuclear instrumentation, and model-locked lasers capable of generating pulses of a few picoseconds duration.

Presently, waveforms are characterized by either oscilloscopic techniques or pulse-comparison techniques. Oscilloscopes fall in two general categories: 1) real-time scopes or 2) sampling scopes. Real-time scopes have limited bandwidth and sensitivity. Sampling scopes ex-



Pyroelectric autocorrelator employing weak-signal enhancement.



Pyroelectric detector mounted in coaxial holder.

Autocorrelator mounted on support bench.

hibit broader bandwidth and higher sensitivity but lack stability.

Pulse-comparison techniques involve comparing the pulse with itself (e.g., autocorrelation) or another waveform (e.g., cross correlation). Some earlier instruments embodying these techniques had bandwidth limitations.

Measuring the autocorrelation function of any time-domain waveform requires that the waveform be delayed with respect to itself, multiplied by the undelayed part and the product integrated over all time that the product is not zero. In principle, all

these functions must be performed independent of time which requires that the devices producing the delay and multiplication (i.e., the sliding short and detector) not be bandwidth limited.

The new pulse autocorrelator is a pulse-comparison circuit that achieves the required bandwidth in the autocorrelation process by employing a thin-film broadband pyroelectric energy detector to perform the squaring and hence multiplying function. The delayed, reflected wave combines with the incident wave in the pyroelectric detector to be squared by the mul-

tiplier and integrated by the detector capacitance. The sliding short produces the required delay and overcomes the bandwidth limitations of the signal-splitting tee and pads of earlier autocorrelation methods.

By using a pyroelectric detector and weak-signal enhancement methods, the improved autocorrelator can, in effect, perform uniform time stretching, hence permitting the fast transition-time information that is contained in repetitive pulses to be measured with devices having a slow response time and high sensitivity.

Art

continued

ferences in the lifelines of the above reactions, lead in different geological environments will acquire different (though not necessarily unique) isotopic compositions, which change continuously as long as the lead remains in the original environment. However, when lead becomes separated from the parent uranium and thorium during the process of ore formation (as almost always happens), the lead isotopic

composition becomes "frozen" and ceases to change.

Current research is in a stage wherein every sample not only reveals something new but also may have a bearing on the interpretation of prior data, occasionally in an unexpected way. As in many other archaeological undertakings, new facts sometimes clarify and sometimes tend to befog the overall picture.

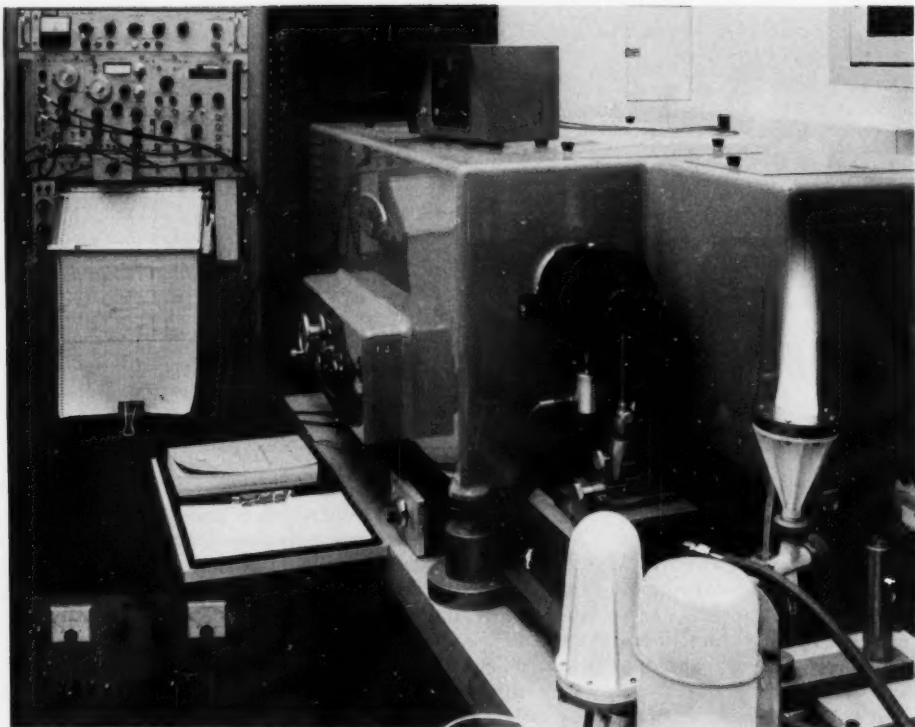
A source of evidence for archeologists and historians, lead isotope studies can now be seen to benefit numismatists. With their help, the investigation of silver and gold coins will be especially emphasized in the future by the NBS team.

Expansion of the NBS source data bank depends upon the cooperation of archeologists and other interested parties. This will enhance their ability to locate sources of materials for the manufacture of ancient objects and contribute to piecing together the story of ancient civilizations.

¹ Barnes, I. L., Shields, W. R., Murphy, T. J., and Brill, R. H., Isotopic Analysis of Laurium Lead Ores. Fifth Symposium on Archaeological Chemistry, sponsored by the Division of History of Chemistry, American Chemical Society, Dallas, April 9 and 10. To be published as part of The Advances in Chemistry Series of the American Chemical Society, Washington, D.C.

² Brill, R. H., and Shields, W. R., Methods of Chemical and Metallurgical Investigation of Ancient Coinage, Royal Numismatic Society, Special Publication No. 8, London, 1972.

NBS flame spectrometer for simultaneous multielement emission and atomic absorption measurements.



NEW CLINICAL CHEMISTRY PROGRAM ANNOUNCED

NBS is joining forces with the Center for Disease Control (CDC), U.S. Department of Health, Education, and Welfare, in a major effort to improve measurement systems used in the clinical diagnosis and treatment of diseases. These agencies will produce Standard Reference Materials (SRM's) and develop referee methods to improve the reliability of chemical analyses in clinical laboratories.

Expressing the need for such standards, Dr. D. Young of the National Institutes of Health commented, "While day-to-day...reproducibility...is necessary for results to be meaningful within single institutions, it is essential that the results are also accurate if they are to have long-term validity

or are to be compared with results from other laboratories." At a recent conference held at NBS, a more direct appeal was made by Dr. J. R. Penton of the Research Institute of Laboratory Medicine, Institute of Medical Sciences, San Francisco, who stated, "We suggest that NBS consider the production of reference sera with values for the common routine determinations assigned through use of their own SRM's and referee methods."

In response, the Bureau and CDC through an Interagency Agreement have set up a program. The CDC will use its expertise in the development of biological materials to prepare stable, sterile sera. These sera will be designed to constitute a unique set with special analytical

characteristics for the evaluation of clinical electrolyte methods and standardization. The NBS Analytical Chemistry Division will analyze them for accuracy and long-term stability. At least two independent methods will be used to certify values for sodium, potassium, magnesium, calcium, chloride, and lithium in individual sera solutions. These efforts at NBS include the design, construction, and computer interfacing of a multichannel flame emission and atomic absorption spectrophotometer for the simultaneous determination of these elements.¹

After certification, these SRM's can be used by manufacturers of secondary standard materials, e.g., control sera used for daily calibra-

tion of automated analyzers, to help assure the accuracy and quality of their products. The SRM's also provide basepoints that clinical laboratories may use to determine whether their tests made on the same materials are accurate. From these determinations they will know what their margin of error is and can correct it. The use of such SRM's should reduce the margin of possible error in analyses made by clinical laboratories of pharmaceutical firms, hospitals, universities, and private research organizations.

Additionally, the cooperative program will involve the development of referee methods. These referee methods are analytical test methods of demonstrated accuracy. They are used in conjunction with NBS-SRM's to test and assure the accuracy of routine methods used in clinical chemistry laboratories. Through the laboratory improvement programs of the CDC, the long-term integrity of the measurement processes will be assured. NBS and CDC, in cooperation with leading clinical chemists and pathologists, are making plans to develop, test, and validate referee methods for each constituent of the electrolytic sera. (A referee method for calcium has already been established.²)

Overall, the main concern of the program is to make certain that accurate clinical measurements for the diagnosis of disease and treatment of patients are obtained on a routine basis. This work should also help improve interlaboratory comparisons and guarantee compatibility of test results obtained over an extended period of time.

¹ Mavrodineanu, R., Analytical Coordination Chemistry Section: Summary of Activities July 1969 to June 1970, Nat. Bur. Stand. (U.S.) Tech. Note 544, O. Menis and J. I. Shutz, Editors (Sept. 1970). Order by SD Catalog No. C13.46:544 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for \$1.25.

² Cali, J. P., Mandel, J., Moore, L., and Young, D. S., A Referee Method for the Determination of Calcium in Serum, Nat. Bur. Stand. (U.S.) Spec. Pub. 260-36, 121 pp. (May 1972). Order by SD Catalog No. C13.10:260-36 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for \$1.25.

Microcalorimetry Applied to Clinical Chemistry

DEVELOPMENT of a unique and versatile clinical diagnostic tool based on heat measurement with promising potential for automated health-care applications is under way at NBS, sparked by the National Institute of General Medical Sciences. The idea is to measure

components of biological fluids by the heats of their reactions.

Early studies at NBS indicate that the technique, called microcalorimetry, is as accurate as other methods. The versatility of the method is what makes it potentially

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Heat-of-reaction measurements can give accurate clinical and biochemical quantities in new microcalorimeter shown by chemist Ruby Boyd of NBS.



MICROCALORIMETRY *continued*

applicable to a wide range of components, and there is evidence that the technique can be incorporated into automatic analyzers.

The current one billion annual individual diagnostic tests in the United States are expected to double in number in a decade. With increasing needs by physicians for tests for different substances, the versatility of microcalorimetry makes it especially attractive.

THEORY & TECHNIQUE

Enthalpy (heat) effects are observable in all reactions of biologically active substances. Thus, with small amounts of human fluid, such as blood serum, using a microcalorimeter, it is possible to detect reactions of very small quantities of substances present. The new NIH-NBS method uses an enzyme to cause selective reaction of a single substance in the serum.

For several years, NIH researchers under Dr. Robert L. Berger of the National Heart and Lung Institute have been exploring heat-of-reaction measurements as a clinical diagnostic tool. NIGMS partially funded formal collaboration with the NBS Thermochemistry Section. This collaboration got under way at NBS during the summer of 1972 under the general supervision of Dr. George T. Armstrong. NBS scientists involved in the program are Edward J. Prosen, Dr. Robert N. Goldberg, Dr. Bert R. Staples, Ruby N. Boyd, and Gail R. James.

What they were looking for was "a technique which could provide improved accuracy and reliability, acceptable speed, and especially the ability to monitor a variety of substances for which analytical procedures do not yet exist," according to Armstrong.

Using an NIH-designed microcalorimeter as a point of departure, the NBS scientists have developed a new instrument specially suited to

the studies. The chemical reaction is carried out in a small plastic cell in the center of an aluminum block (heat reservoir). The heat from the biochemical reaction passes through highly sensitive thermal detectors located between the cell and the aluminum block, generating an electrical voltage proportional to the rate of heat flow. The rate of heat generation can be determined by measuring the voltage; the total heat generated can be calculated by integrating the voltage with respect to time. The amount of a given substance present and reacting is proportional to the total amount of heat generated.

Plastic cells used in the analysis are interchangeable so that patient samples can be analyzed separately. These cells can be made in an inexpensive, disposable form.

Tests at NBS show that the microcalorimeter is precise to about 0.1 percent. Its thermal sensitivity is very high. It can detect power levels of a fraction of a microwatt and energies of the order of microjoules or a microcalorie (a microcalorie is one-billionth of a weight-watcher's "Calorie"). Only a few drops of fluid are needed for calorimetric measurements—in some cases only 0.01 ml—to detect trace substances present in one part per thousand.

"Effective biomedical use of microcalorimetry calls for finding an enzyme which will cause reaction of a single constituent among the hundreds in a biological fluid," Armstrong, chief of the NBS Thermochemistry Section, explains. "The conversion of glucose to glucose-6-phosphate—a well-characterized enzyme-specific reaction—was chosen to test the principle of the technique." The enzyme is *hexokinase*.

"Preliminary results on more than 50 serum samples indicate that the microcalorimetry results are in good agreement with those obtained using conventional procedures," Armstrong said.

FUTURE WORK

Details of the NBS studies using the hexokinase-catalyzed phosphorylation of glucose are being prepared for publication. Under way now are other preliminary measurements to explore possible applications of microcalorimetry to biomedical problems, such as antigen-antibody interaction, blood-coagulation processes, and bacterial-growth patterns. The thermal growth patterns of bacteria made using the NBS microcalorimeter show greater detail than those made using other calorimeters. This is due to the much faster time constant, the use of smaller volumes of samples, and the greater sensitivity of the NBS instrument.

"The development results from a combination of techniques that have individually been available for some years," Armstrong said. "Improvements in these techniques have been occurring gradually, and the NIH-NBS team has been able to develop them to a stage of sufficient reliability, sensitivity, and simplicity to make a practical procedure."

The experimenters see in the new technique several potential advantages for clinical medicine and research, including versatility and applicability to a wide range of biologically active substances.

"Microcalorimetry promises to provide an absolute method in that measurements can be based on a volt-second-joule system rather than on a calibration curve," Armstrong said. "This should provide a better standard of measurement; a more quantitative measure."

Interest in the project is keen and several microcalorimeters have now been placed in United States and European laboratories. Now that the microcalorimetric method has been shown to be applicable to clinical analysis, the NIH and NBS scientists are searching for situations in which it will be especially advantageous.



Minicomputerized surface roughness measurement device being demonstrated on a gage block by Sandra J. Wilson.

COMPUTERIZED SYSTEM MEASURES SURFACE ROUGHNESS

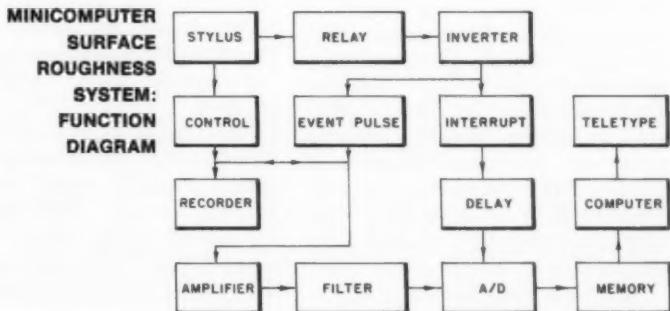
A minicomputerized system, developed by Dr. Dennis Swyt of NBS, provides manufacturers of such items as machine tools, bearings, and microelectronics with more fundamental and accurate measurements of thin films and surface roughness. These more precise measurements may point the way to achieving greater reliability in the products measured.

Until recently, measurements of surface roughness were made by the Bureau's Optical Physics Division using a master physical standard which was subject to loss, damage, and unavoidable degradation. In addition, the physical standard had to have its original roughness value determined by a rather cumbersome method.

The new computerized system for surface measurement will not only routinely make measurements which are more closely related to the basic standard of length, it will also eliminate the undesirable dependence on the physical standard.

Basically, the minicomputerized system consists of a commercial stylus used to generate a profile of the surface roughness, a minicomputer with data acquisition circuitry, and a teletype for system control and output. Calibration of

turn page



SURFACE *continued*

the system involves the measurement of its response to an interferometrically measured gage block or thin-film step. As the stylus passes over the surface of the calibration specimen, the profile is indicated on a strip chart recorder; the signal driving the recorder is amplified, filtered, converted at an appropriate rate to a series of 12-bit data, and stored in memory. The profile of the step is analyzed by fitting least square lines to the opposite side of the step and by computing the distance between the lines at the proper position. A scale factor based on the stylus response and the known value of the calibration step is then calculated.

Subsequent measurements of surface roughness values, or of thin-film thickness derived from individual profiles, are multiplied by the scale factor, converted to decimal, and printed.

For actual measurements, the test specimen is aligned on the stylus instrument, and the teletype queries the operator about the type of specimen. If it is a step discontinuity, the procedure for entering a step is repeated; if it is a roughness measurement, proper filter cutoff and stroke speeds are selected, a code letter is entered at the teletype, and the measurement is made.

The minicomputer system is also being used as an analytical tool for the evaluation of those parameters which may be incorporated into future industrial standards for surface finish characterizations. Further, the system allows for the controlled measurements of thin films which find applications in optical coatings, microelectronics, and similar production processes. The versatility of the system increases opportunities for active participation of NBS staff members in the modernization of industrial standards, a prerequisite to improving the position of American manufacturers in world markets.

PLASTIC JERRY-CAN STANDARD RECOMMENDED

A recommended Voluntary Product Standard for plastic jerry-cans is now being circulated by NBS to interested groups and individuals to determine its acceptability. The purpose of the standard is to establish nationally recognized quality requirements for plastic containers (jerry-cans) used to transport and temporarily store petroleum products.

The Plastic Jerry-Can Committee of the Society of the Plastics Industry, Inc. prepared the proposal upon which the recommended standard is based. Included in the standard are requirements and tests for soft-

ening point, brittleness temperature, flammability, aging, stability, strength, permeability, and petroleum resistance. The standard is being processed by NBS according to the voluntary product standard procedures of the U.S. Department of Commerce.

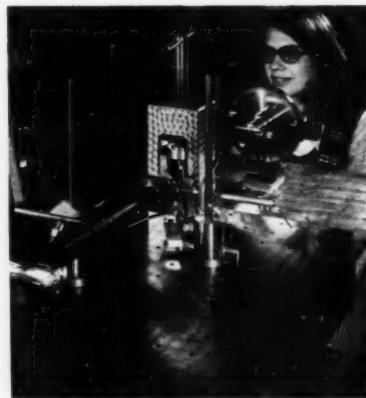
Copies of the recommended Voluntary Product Standard, designated TS 125d, "Polyethylene Plastic Containers (Jerry-Cans) for Petroleum Products," are available from the Office of Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234 (telephone 301/921-3551).

Extra Dense Lead Glass Standard Issued

A new glass standard that will aid glass manufacturers in controlling the quality of their products has just been issued by the Bureau.

The new Standard Reference Material, SRM 709, is an extra dense lead glass that has been certified for the relative stress-optical coefficient as well as for softening, annealing, and strain points.¹ The physical property values were obtained by NBS and two commercial laboratories using ASTM test methods.

This SRM is one of a series developed by members of the Bureau's Inorganic Glass Section to provide common reference points for glasses of the same or similar composition. Such glass standards are needed by the glass industry to



Susan Mills of the Inorganic Glass Section uses a polarimeter to determine the relative stress-optical coefficient of a glass Standard Reference Material.

promote uniformity of measurement and to check or calibrate instruments and furnaces to ASTM specifications.

¹SRM 709 may be purchased from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234, for \$70. Information on other SRM's is available at the same address.

ARPA/NBS SEMICONDUCTOR WORKSHOP HELD

THE Defense Advanced Research Projects Agency (ARPA), U.S. Department of Defense, and NBS announced a major new program addressing critical Defense Department problems in the yield and reliability of integrated circuits (IC's) in a workshop on September 7, 1973, held concurrently with the fall meeting of American Society for Testing and Materials' Committee F-1 on Electronics.

The new program, "Advancement of Reliability, Processing, and Automation for Integrated Circuits with the National Bureau of Standards" (ARPA/IC/NBS), responds to a need for improved measurement methods and associated technology for controlling and automating key IC processing and assembly procedures and is being developed in concert with the reliability laboratories of the three service

vices. Its major thrusts are the development of well-documented test procedures and measurement technology for use on semiconductor device production lines and the dissemination of such information to the electronics community. Application of the output by industry is expected to result in higher yields, lower cost, higher reliability, and greater availability of special devices needed by the Department of Defense.

The new program will be an ARPA activity in the NBS Joint Program on "Methods of Measurement for Semiconductor Materials, Process Control, and Devices" now being conducted in cooperation with a number of Defense Department agencies. The widely distributed series of quarterly reports from this Program is to be continued and retitled "Semiconductor

Measurement Technology." A feature of the expanded Program will be the contracting of selected work to other government laboratories, industry, universities, and private research laboratories.

This workshop, first of a series, focused on nonproprietary measurement problems in which semiconductor device manufacturers, their suppliers, and their customers share a concern. The morning session featured presentations on: the ARPA/IC/NBS Program; earlier activities of NBS in electronic measurement technology; and some conclusions drawn from discussions with industrial representatives regarding needed process control improvements. In the afternoon, small groups were formed to discuss specific process control problems and measurement needs.

PUBLICATIONS

Atomic and Molecular Studies

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Artru, M.-C., Kaufman, V., Re-evaluation of parameters for even configurations of triply ionized magnesium, *J. Opt. Soc. Amer.* 63, No. 4, 449-450 (Apr. 1973).

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